6-1977

Relationships Between Central Auditory Function and Learning Disabilities

Joan M. Hirabayashi

Abstract

RELATIONSHIPS BETWEEN CENTRAL AUDITORY FUNCTION
AND LEARNING DISABILITIES

by Joan M. Hirabayashi

The purpose of this study was to compare the performance of "learning disabled" (LD) children and children with no identified learning problems on tests of central auditory function. Katz's Staggered Spondaic Word (SSW) test and Willeford's Tests of Central Auditory Function (TCAF) were administered.

The groups consisted of twenty-one LD children (experimental) and twenty-one children with no identified learning problems (control). The groups were matched for age, sex, socioeconomic background, and IQ. None of the subjects had a peripheral auditory impairment.

Experimental and control groups differed significantly on the corrected left SSW ear scores at the 0.03 level, the corrected total SSW scores at the 0.05 level, and on the left ear scores of the Competing Sentences test of Willeford's TCAF at the 0.05 level.

Discriminant analysis showed that five variables predicted whether an individual child belonged to the experimental or control group. This led to a formula that predicted correct group membership seventy-three and eight tenths percent (73.8%) of the time.

LOMA LINDA UNIVERSITY

Graduate School

RELATIONSHIPS BETWEEN CENTRAL AUDITORY FUNCTION AND LEARNING DISABILITIES

by

Joan M. Hirabayashi

A Thesis in Partial Fulfillment
of the Requirements for the Degree
Master of Science in the Field
of Audiology

June 1977

Each person whose signature appears below certifies that this thesis in his/her opinion is adequate, in scope and quality, as a thesis for the degree Master of Science.

E. Evelyn Britt

E. Evelyn Britt, Associate Professor of
Speech Pathology and Audiology

Victor S. Griffiths

Victor S. Griffiths, Professor of
English

David G. McGann

David G. McGann, Audiologist

Wilma F. Phillips

Wilma F. Phillips, Assistant Professor
of Curriculum and Instruction,
School of Education

ACKNOWLEDGMENTS

Sincere appreciation for their help is expressed to the administrators of the Jurupa Unified School District, Mr. Kendall Butler of the La Sierra Elementary School, and parents for making subjects available; to the children for the participation in the study; to Dr. Wilma Phillips for her assistance in designing the study; to Mr. Carlyle Flemming for his help in analyzing and interpreting the data; and to Dr. Victor Griffiths and Mr. Dave McGann for their suggestions, encouragement, and support.

Special appreciation is expressed to Dr. E. Evelyn Britt for her invaluable guidance and support throughout the study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

A battery of existing audiometric tests (pure tone and speech audiometry, tone decay, short increment sensitivity index, loudness balance, Bekesy) consistently detects lesions in the peripheral auditory system. These tests have been well accepted. In 1954 Bocca and his associates began devising special speech tests which stress the auditory system for purposes of detecting temporal-lobe tumors (Bocca, Calearo, and Cassinari, 1954). Since this time, others have experimented with tests to study central auditory nervous system (CANS) function (Calearo and Antonelli, 1968; Mencher, 1970; Smith and Resnick, 1972; Korsan-Bengtsen, 1973). The primary purpose of these studies was to investigate the functions of the CANS by observing how the tests are affected by surgically confirmed lesions in the CANS. These tests are not generally recommended as diagnostic tools with the possible exception of the Staggered Spondaic Word (SSW) test by Katz (1962, 1968).

Recently, investigators have turned their attention to the use of some of these tests to assess central auditory difficulties encountered in children with "learning disabilities." Particular attention has been given to the tests of Katz (Stubblefield and Young, 1975) and Willeford (1976).

Statement of the Problem

Stubblefield and Young (1975) showed that "learning disabled" (LD) children made significantly more errors than what is accepted for normal performance on the SSW test. The study compared the performance of normally achieving children with LD children who were between the ages of seven and nine years of age.

Willeford (1976) published an article regarding the application of his tests to the assessment of children with learning disabilities. No controlled study has been published, however, comparing normal and LD children.

Purpose

The purpose of this study was four-fold: (1) to determine if SSW test scores of LD children are significantly different from those of children with no identified learning disabilities, (2) to determine if the scores of tests of central auditory function (TCAF), as described by Willeford, of LD children are significantly different from those of children with no identified learning disabilities, (3) to determine if there is a relationship between scores of LD children on the SSW test and TCAF, and (4) to establish normative information which would set criteria for differentiating the normal child from the LD child.

Hypotheses

Four hypotheses were posed for this investigation. (1) The scores on the SSW test would be significantly different for LD children than for children with no identified learning disabilities. (2) The scores on the TCAF would be significantly different for LD children than for children with no identified learning problems. (3) There would be a high correlation between scores of LD children on the SSW test and the Competing Sentences test of the TCAF. (4) There would be identifiable points on the SSW test and on the TCAF which would separate the scores of children identified as LD and those who have no identified learning problems.

Definition of Key Terms

Peripheral auditory system: the auditory system which includes the external ear, the middle ear, the inner ear and the eighth cranial nerve up to the cochlear nuclei of the brain stem.

Central auditory nervous system (CANS): that portion of the auditory system extending from the cochlear nuclei of the brain stem to and including the auditory cortex in the temporal lobe.

Dichotic listening: two different messages presented simultaneously, one to each ear.

Staggered Spondaic Word (SSW) test: a dichotic listening task, each ear receiving different spondaic words from well separated channels. The first syllable of the second word overlaps the second syllable of the first word.

Tests of Central Auditory Function (TCAF): Competing Sentences (CS) test, Binaural Fusion (BF) test, Filtered Speech (FS) test, and Alternating Speech Perception (AS) test, described by Willeford (1976).

CHAPTER 2

REVIEW OF THE LITERATURE

The auditory process of hearing and understanding speech is complex. Normal discrimination is possible even in the absence of certain speech sounds because messages from both cochleas are received in each auditory cortex by way of crossed and uncrossed auditory pathways. Even patients with lesions of the auditory cortex have been found to have normal speech perception (Nylen, 1939; Bocca et al, 1954; Bocca, Calearo, Cassinari, and Migliavacca, 1955; Bocca and Calearo, 1963; Jerger, 1960a; Korsan-Bengtsen, 1973; and others).

Tests most successful in identifying CANS dysfunction are those that stress the auditory system by reducing the redundancy of speech. Bocca, Calearo, and Cassinari (1954) laid the ground work for various types of low-redundant speech tests. The speaker's voice was filtered through a low pass filter set at 800 Hz. This distorted the message so that patients with tumors in the auditory area of one of the cortices gave reduced discrimination scores in the contralateral ear. These patients showed normal performance on the usual pure tone and speech audiometric tests.

A few years later, Bocca (1958) employed a more elaborate group of tests which distorted, interrupted, or accelerated speech. A "long message test" (long sentences) was also part of this group. To reduce redundancy of normal speech, others have split, competed, and reversed words and sentences (Berlin and Lowe, 1972).

The effects of interrupted speech tests have been investigated by Bocca (1958), Calearo and Antonelli (1963, 1968), Antonelli (1970), and Jerger (1970). Depending on the number of interruptions per second, discrimination scores were reduced about fifteen to twenty-five percent in patients with unilateral temporal lobe lesions and with brain stem lesions.

Time-compressed speech tests have also been extensively researched (Garvey, 1953; Calearo and Lazzaroni, 1957; Fairbanks, Guttman, and Miron, 1957; Bocca, 1958; de Quiros, 1964; and Korsan-Bengtsen, 1968, 1970, 1973). Those studies done on patients with lesions of the CANS showed a reduction in discrimination scores in ears contralateral to the side of lesions in the auditory cortex.

Katz's test and Willeford's tests were used in this study. Since their tests consist of dichotic listening, filtered speech, binaural fusion, and alternating speech, these types of tests are reviewed in more detail.

Dichotic Listening Tests

Kimura (1961a) simultaneously presented different verbal stimuli to the ears of patients with epileptic seizures. Patients had atrophic lesions in the left temporal lobe, the right temporal lobe, the frontal lobe, or below the cortex, and were grouped accordingly. Digits were presented in groups of six, three to the right ear and three to the left ear. Subjects were asked to repeat all the numbers they heard after the presentation of each group. Digits could be repeated in any order. The left temporal lobe group had poorer digit spans than did the right temporal lobe or frontal lobe groups. Kimura concluded that the left temporal lobe is particularly important in the auditory perception of verbal material.

The same procedures were applied to patients with epileptogenic lesions (1961b). Again, the subjects were divided into groups according to the location of the lesions. Individuals without lesions were also tested. The results were consistent with the previous findings.

Temporal lobectomy patients were studied by Oxbury and Oxbury (1969). The results of this study tended to support Kimura's findings.

Katz (1962) devised the Staggered Spondaic Word (SSW) test in which the second part of the first word is presented simultaneously with the first part of the second word. Since the words are only partially overlapping, the order in which the subject repeats the two spondaic words is significant. Katz (1968) conducted a pilot study comparing subjects having normal hearing, unilateral trauma to the head, conductive hearing losses, and sensorineural hearing losses. Control subjects, i.e., those with normal hearing, and subjects with conductive hearing losses had little or no difficulty in completing the task. Subjects with moderate to severe sensorineural hearing losses showed marked difficulty on this test, as they would on any discrimination task. The group demonstrating the most difficulty was the unilateral head trauma subjects. They made a considerably greater number of mistakes in the ear contralateral to the injury.

Jerger (1964) simultaneously presented sentences to one ear and phonetically-balanced words to the opposite ear. Discrimination scores of patients with lesions in the CANS were reduced. A reduction in discrimination scores did not occur in patients with lesions in other parts of the brain.

The belief that the left hemisphere is dominant for speech in the right-handed has been in existence over a hundred years (Penfield and Roberts, 1959). Broadbent (1954) first reported that in dichotic listening, the right ear perceives messages more accurately than the left. It was not until 1961 that right ear advantage (REA) in dichotic listening tasks was reported to be due to the dominance of the left hemisphere for speech and the crossing of auditory pathways (Kimura, 1961b). Many studies have been published on REA for auditory stimuli and hemispheric asymmetries since 1954 supporting the concept of dichotic REA for speech (Triesman and Geffen, 1968; Gerber and Goldman, 1971; Sussman, 1971; Berlin, Lowe-Bell, Cullen, Thompson, and Loovis, 1973; Cullen, Thompson, Hughes, Berlin, and Samson, 1974; Ryan and McNeil, 1974).

Several reasons have been advanced for REA. Berlin and McNeil (1976) suggest the following factors: (1) morphologic and functional asymmetry, (2) selective attention, (3) memory or storage model, (4) vocal tract gesture coding, (5) perceived source of auditory space, and (6) temporal sequencing as a left hemisphere function. They feel that probably all of these factors interact, but just how and to what extent remains unclear.

Filtered Speech Tests

As previously stated, Bocca, Calearo, and Cassinari (1954) showed that patients with tumors in the auditory area of one of the cortices gave reduced discrimination scores in the contralateral ear when frequency-distorted or filtered speech tests were used. In 1955, Bocca et al confirmed these findings in twelve of eighteen patients with unilateral temporal lobe lesions. The six patients who gave similar results in both ears were found by subsequent surgery to have lesions in areas not affecting the CANS.

Matzker and Ruckes (1958) presented low pass filtered speech to one ear and high pass filtered speech to the opposite ear. Patients with brain stem lesions showed reduced discrimination scores.

Jerger (1960b) compared Parkinsonian patients with controls on two central auditory tests. He used low pass filtered speech and speech with alternating masking index (SWAMI). The cut-off frequency of the low pass filtered speech was 500 Hz. The SWAMI was made by presenting alternating bursts of white noise over the speech stimuli at the rate of one per second. The noise was 20 dB more intense than the speech. He found that Parkinsonian patients performed less well than controls on both central auditory tests.

Calearo and Antonelli (1963) used a low pass filter with a cut-off frequency of 500 Hz. This resulted in a twenty to forty percent reduction in discrimination scores for the contralateral ear in patients with unilateral right or left temporal lobe lesions.

Eleven patients with right-sided temporal lobe epilepsy were studied by Calearo and Antonelli in 1968 using the filtered speech test pre-operatively and post-operatively. The discrimination scores were poorer after the operations, with or without the removal of Heschl's gyrus. The cause of this was attributed to secondary defects in the CANS due to disease or surgery.

Other researchers who have employed filtered speech tests and demonstrated poor performance in the ear contralateral to the site of lesion are Jerger (1964), Berlin, Chase, Dill, and Hagepanos (1965).

Binaural Fusion Tests

Binaural fusion tests are comprised of two portions of a monaural message. Half of the message goes to one ear, half to the other. Each portion by itself is inadequate for identification. Presented simultaneously, the message is clear.

Bocca et al (1955) presented a filtered low pass message of sufficient intensity to one ear and normal speech at subliminal intensities to the other ear. The scores of subjects with lesions in the auditory cortex did not exceed fifty percent on this binaural fusion task while normals had no difficulty.

In 1959 Matzker presented low pass filtered speech (500-800 Hz) to one ear and the same message filtered through a high pass filter (1815-2500 Hz) to the other ear. Normal subjects listening to the message through one band only scored twenty-five to thirty percent, but had no difficulty listening to it binaurally. Eighty percent of patients with brain tumors obtained decreased scores.

Alternating Speech Perception Tests

Periodically switching of the message from one ear to the other so that each ear receives half of the message is a type of binaural fusion test. This was first done by Cherry and Taylor (1954). Persons considered to be normal showed a reduction in discrimination scores when the rate of switching was approximately four interruptions per second. A mental delay caused by a switch in attention from one ear to the other was thought to be the reason for the reduction.

Bocca (1961) and Bocca and Calearo (1963) reported that discrimination scores of normal subjects are always between ninety and one hundred percent regardless of the rate. He administered his test to three groups of subjects having widely varying scores in tests of intelligence, memory, and vocabulary. He found that vocabulary and memory of subjects affected test results when long sentences were presented, but that intelligence of subjects and quality of the message did not. Findings of Bocca and his associates did not confirm those of Cherry and Taylor. No reductions of discrimination scores were found either in normal subjects or in pathological cases at any output speed. Patients with auditory cortex pathologies did not show any reductions of discrimination scores. However, a considerable number with pathologies of the brain stem and some with diffuse cerebral pathology performed more poorly using this alternating speech test. They felt this proved that fusion of messages from two ears was at a subcortical level.

Staggered Spondaic Word Test and Learning Disabilities

Central auditory dysfunction in learning disabled children was studied by Stubblefield and Young (1975). Ten boys and ten girls between the ages of seven and eleven years who were classified as LD children at their schools were in the study group. Children in the comparison group were identified by their teachers as having normal academic achievement. Subjects of both study and comparison groups were matched for sex, age, socioeconomic background, and IQ. They had no physical disabilities.

Peripheral auditory system function was tested on all subjects with standard audiometric procedures of air conduction tests and speech audiometry. None were found to have any peripheral hearing problems. The SSW test was administered by an audiologist using standard procedures.

Children in the comparison group gave scores within the standardized norms. The difference between scores of LD children and normally achieving children was found to be significant at the .01 level.

Stubblefield and Young recommended that children, seven years or older, who make more errors than the standardized norms, be considered as possibly learning disabled. They suggested that a screening version of this test could be developed. For example, criteria for passing the screening test might be zero errors in the first five presentations. Similarly, children making at least one error in the first five presentations or three errors in the first ten presentations probably should be tested with the entire SSW test. This screening test apparently has not yet been refined.

Willeford's Tests of Central Auditory Function and Learning Disabilities

Descriptions of Willeford's tests were published in 1976. The performance of adults with surgically confirmed brain lesions has been studied by Dr. George Lynn and his colleagues at the Wayne State University Medical School using these tests. A few typical cases were presented. For example, a patient with an astrocytoma in the right parietal lobe gave a significantly poorer performance in the left ear on the competing sentences task. A patient with an astrocytoma in the left temporal lobe performed poorly in his right ear on the same task. Dr. Lynn and his group studied over three hundred cases of confirmed brain lesions. They felt that dichotic competing sentences are consistent in identifying lesions in posterior areas of the temporal lobe and that distorted speech (filtered speech) tests are sensitive in identifying lesions in the lower regions of the temporal lobe.

Willeford (1976) found that nine children grossly labeled as LD did poorly on one or more of the four tests in one or both ears. He did not draw any conclusions from these findings, but did say that "a lot of work lies ahead before we fully understand auditory processing, especially in LD children."

Summary

It has been shown that tests of central auditory function designed to reduce the redundancy of verbal stimuli provide useful information in the diagnosis of surgically confirmed central auditory pathologies. Only two of the studies reviewed dealt directly with the use of these tests on learning disabled children. One of these, that of Stubblefield and Young (1975), used matched groups. No comparable study has been done using TCAF and no study has been done comparing the SSW test with Willeford's TCAF.

CHAPTER 3

METHOD

Sample

This study consisted of an experimental group and a control group, each composed of twenty-one children between the ages of eight and twelve years. It was originally planned that the sample would contain an equal number of male subjects and female subjects. Because of the higher incidence of learning disabilities among male individuals, it was impossible to find equal numbers from the sample population. All subjects had normal peripheral hearing of 15 dB HL or better, as tested by air conduction audiometry.

The experimental group consisted of children who were randomly chosen from a pool of sixty-one children in the Jurupa Unified School District identified according to the California code (1976) as being LD. After subjects for the experimental group were chosen, twenty-one children from the La Sierra Elementary School, who had no identifiable learning problems according to their classroom teachers, were chosen for the control group.

The groups were matched for sex, age, i.e., within six months, and socioeconomic background, i.e., based on occupation of the head of the household (Warner, 1949). Although they were matched, only skilled and unskilled laborers were represented in the sample. Of the twenty-one subjects, sixteen were matched for IQ. See Appendices B and C for descriptions of the sample.

Materials

The Slosson Intelligence Test was used to determine IQs of the subjects. Because some of the LD children had been tested with the Wechsler Intelligence Scale for Children (WISC), others had been administered the WISC-Revised, and many of the scores were two years old, it was felt that results from the schools could not be used to compare the IQs of the two groups. The Slosson Intelligence Test was chosen to retest the experimental group and to test the control group for IQ because it correlates highly with the Stanford-Binet Intelligence Scale, Form L-M (Armstrong and Jensen, 1971) and the Wisc-Verbal (Armstrong, Jensen, and Reynolds, 1974), it is easy to administer and score, and it is short.

The SSW test and TCAF were used to test for central auditory function. The SSW test consists of spondaic words selected for familiarity with competing elements of equal duration and with non-competing elements forming a third spondaic word. The words are presented dichotically in such a manner that the final portion of one spondee overlaps the initial portion of the other spondee. The subject is expected to repeat both spondaic words in the order of presentation. The SSW test was administered and scored at the time of testing, according to Katz's manual of instructions.

Four tests of TCAF are the Competing Sentences test and Filtered Speech test for cortical dysfunction, and the Binaural Fusion test and Alternating Speech Perception test for brain stem dysfunction. They were scored at the time of testing, according to procedures outlined by Willeford.

The Competing Sentences test is composed of simple sentences. A primary sentence is presented to the test ear and a secondary sentence is presented to the opposite ear. The subject is asked to repeat the primary message which is presented at a softer level (S/N of -15).

The Filtered Speech test is a monaural frequency-distorted test consisting of Michigan CNC (consonant-nucleus-consonant) words passed through an electronic filter set to pass only those frequencies below 500 Hz. The task is to repeat the words correctly. A carrier phrase, "You will say," is used to monitor the delivery of each word. The subject is cautioned that the words are difficult to understand and is encouraged to guess.

The Binaural Fusion test consists of special spondaic words. A low-band-pass segment (100-700 Hz) recorded on Channel I is presented to one ear while a high-band-pass segment (1900-2100 Hz) recorded on Channel II is presented to the other ear. The procedure is then reversed using a second list. In the Alternating Speech Perception test the subject is asked to repeat the sentences which are presented in alternating bursts of 300 msec. durations first to one ear, then to the other.

Testing was done in an IAC (Industrial Acoustics Company) Series 400 ATC two-room sound suite using a Grason-Stadler diagnostic audiometer Model 1701 equipped with a half track reel-to-reel tape recorder. Stimuli were presented through TDH-49 earphones. Calibration of the audiometer was checked prior to each day's clinical testing using a 2cc coupler connected to a Fonix electroacoustic analyzer.

Procedures

Pure tone air conduction audiometry and speech audiometry were administered to all subjects. The purpose was to see if they would be included in the study and to obtain data necessary to administer the SSW test and TCAF. The following were randomized: (1) the SSW test and TCAF, (2) Competing Sentences test, Filtered Speech test, Binaural Fusion test, and Alternating Speech Perception test, and (3) order of ear presentation on pure tone audiometry, speech audiometry, SSW test, and TCAF.

To test the reliability of the examiner's judgments, a random sample of recordings of subjects from each group was scored by two certified audiologists who did not know from which group the subjects' recordings were selected. The scoring results of the three ratings were compared for between-judge agreement. A between-judge agreement of ninety percent was the criterion for inter-judge reliability and freedom from bias.

<u>Pure tone audiometry</u>. Pure tone thresholds (air conduction) were obtained bilaterally at 500, 1000, 2000, and 4000 Hz. The Carhart-Jerger procedure (Martin, 1975) was used. Pure tones were presented for two seconds. The attenuator was not adjusted while tones were being presented. A pure tone at 1000 Hz was presented at 40 dB HTL. If the subject did not respond, it was raised to 70, 85, and 100 dB HTL or

until the patient responded. The tones were lowered in 15 dB steps until they were no longer heard, then they were raised in 5 dB steps. If the tones were heard, they were lowered in 10 dB steps. The lowest level at which the subject responded twice following this procedure was considered his threshold. These procedures were repeated at 2000, 4000, and 500 Hz, in that order.

Instructions given were: "You will hear some beeps in your ears, first in your right/left ear, then in your left/right ear. I want you to raise your hand as soon as you hear them and put your hand down as soon as they are gone. The beeps will get softer. I am looking for the softest beep you can hear."

Speech reception thresholds. A record of CID Auditory Test W-1, List E, recorded by Technisonic Studios was used to obtain the speech reception threshold (SRT) for the first ear. List F was used to obtain the SRT in the other ear. The 1000 Hz calibration tone on the W-1 record was set to the reference point (0) on the VU meter. Instructions to the subject were: "Say the words that the man says. His voice will get softer and softer. I want you to guess at the words you can barely hear." The same procedure used to obtain pure tone thresholds was used to obtain SRTs.

Speech discrimination. Speech discrimination scores in quiet were obtained using a record of CID W-22 words, recorded by Technisonic Studios. The 1000 Hz calibration tone of the record was set to the reference point on the VU meter. The subject was instructed: "Now I want you to repeat the last word that the man says." The instructions were repeated or rephrased until the subject understood the task. Phonetically-balanced (PB) words, List 3C, were presented to one ear at 40 dB above the SRT. If the subject missed only one or two words of the first twenty-five words, the second half of the test was eliminated. If he missed more than two, the second half was used. The percent correct was the discrimination score. List 3D was used in testing discrimination in the opposite ear.

The same procedures used in obtaining discrimination scores in quiet were used to determine speech discrimination in noise. The signal-to-noise (S/N) ratio was -10. Speech noise was presented to the non-test ear. Lists 4C and 4D were used to obtain discrimination scores in noise in the first and second ears, in that order. The subject was told: "You will hear noise in your right/left ear. Do not pay attention to it. Keep repeating the words like you have been doing."

SSW test. The 1000 Hz calibration tone on the SSW test was set to 0 on the VU meter of the audiometer. Stimuli presented through Channel I were presented to the first ear at 50 dB re. SRT in that ear. Stimuli presented to the opposite ear through Channel II were presented at 50 dB re. SRT in that ear. The following instructions were provided: "You are going to hear four words and I want you to repeat all four of them. Two of them are going to be said at the same time, so you must listen carefully. Are you ready?" The tape recorder was stopped if it was necessary to give the subject additional time to respond.

TCAF - Competing Sentences test. The primary messages were presented through Channel I at a sensation level (SL) of 35 dB re. pure tone averages. The competing messages were presented through Channel II at 50 dB SL. The examiner said, "You are going to hear some sentences in your right/left ear that are going to be softer than the ones in your left/right ear. I want you to listen to the sentences in your right/left ear and tell me what the man says.

If the subject failed the first item, the tape was stopped and he was asked, "Which ear are you listening with?" If he pointed to the correct ear, the examiner said, "Good. Tell me what you hear in that ear." If he pointed to the incorrect ear or if he failed to point to either ear, the examiner said, "This is your right/left ear (pointing). Tell me what the man says in this ear." The next ten items were presented to the subject's first ear and the following ten were presented to the opposite ear.

If the subject was slow to respond, the examiner stopped the tape recorder and allowed adequate time for him to respond. Responses were scored correct or incorrect. Samples of incorrect responses are: "I don't know." "I couldn't hear it." "I couldn't understand." Responses mixing contents of two messages were scored incorrect. If the subject changed the sentence but kept the content of the sentence, the response was scored correct.

TCAF - Filtered Speech test. List #1 was presented to the first ear and list #2 was presented to the opposite ear at 50 dB SL re. PTA. Presentation was through Channel I. Instructions were: "Repeat the words that the man says. The words are going to be hard to understand. Just do the best you can.

TCAF - Binaural Fusion test. List #1 was presented, the low-band-segment through Channel I to the first ear and the high-band-segment through Channel II to the opposite ear. Channel I was set at 30 dB SL re. his pure tone threshold at 500 Hz for the first ear. Channel II was set at 30 dB SL re. his pure tone threshold at 2000 Hz for the opposite ear. The examiner said, "Repeat the words that the man says." If the subject pluralized any word or changed a word to past tense by adding "d" or "ed," it was scored correct. The same procedures were followed for List #2 except that the second ear received the low-band-segment through Channel I while the first ear received the high-band-segment through Channel II.

TCAF - Alternating Speech Perception test. Stimuli were presented at 30 dB SL re. PTA to the first ear through Channel I and to the opposite ear through Channel II. Instructions were: "Repeat the sentences for me." Adequate time was allowed for the subject to respond. The tape recorder was stopped as needed and the stimulus was repeated. A response was scored correct if it contained the essential meaning of the stimulus.

Analyses of the Data. An IBM OS 360 computer, Statistical Package for the Social Sciences (SPSS), was used to analyze the data. Pearson product moment correlation, t test, and discriminant analysis subroutines were employed.

CHAPTER 4

RESULTS

Samples of the responses were scored by two judges and a between-judge agreement of ninety-five percent was found. Both judges were certified audiologists. The criterion of acceptability that had been selected was ninety percent. The following statistical procedures were used to analyze the data: t tests of significance, Pearson product moment correlation, and discriminant analysis.

t Tests of Significance

The t test of significance was used to compare performance of experimental, i.e., LD children, and control, i.e., children with no identified learning disabilities, groups on Katz's Staggered Spondaic Word (SSW) test and Willeford's Tests of Central Auditory Function (TCAF). The scores of the following items were compared:

C-RSSW	Corrected Right SSW
C-LSSW	Corrected Left SSW
C-TSSW	Corrected Total SSW
RCS	Right Competing Sentences
LCS	Left Competing Sentences
RFS	Right Filtered Speech
LFS	Left Filtered Speech
RBF	Right Binaural Fusion
LBF	Left Binaural Fusion

TAS Total Alternating Speech Perception

Using t tests, significant differences were found between the performance of the two groups on the C-LSSW at the 0.03 level and the C-TSSW at the 0.05 level. The hypothesis that there would be a significant difference between the scores of LD children and children with no identified learning disabilities on the SSW test was supported. There was a significant difference between scores of the two groups at the 0.05 level on the Competing Sentences test of the TCAF for the left ear, LCS. There was no significant difference between the two groups on other tests of the TCAF. The hypothesis that scores on the TCAF would be significantly different for LD children than for children with no identified learning problems was supported.

The t values and significance levels are shown in Table 1. The raw scores of the subjects, means and standard deviations are reported in Appendices D, E, F, G, H, I, and J.

Correlation

A Pearson correlation matrix was computed for each group separately and for the two groups combined. For the experimental group, the Pearson correlation coefficient between mean scores of the C-TSSW and RCS was -0.78. The Pearson correlation coefficient between mean scores of the C-TSSW and LCS was -0.76. Both of these are significant at the 0.001 level. See Appendices K, L, and M for correlation matrices and O, P, and Q for significance levels for the correlation coefficients. These findings support the hypothesis that there would be a high correlation between scores of LD children on the SSW test and the Competing

TABLE 1

Mean Comparisons between Experimental and Control Groups on Staggered Spondaic Word Test and Tests of Central Auditory Function

Item	Statistic	Experimental Group	Control Group	df	t*	p
C-RSSW	$\bar{x}$	13.71	5.33	40.00	1.71	0.095
	SD	18.24	13.14			
C-LSSW	$\bar{x}$	16.62	6.24	25.50	2.26	<u>0.033</u>
	SD	19.72	7.38			
C-TSSW	$\bar{x}$	15.10	5.81	27.48	2.10	<u>0.045</u>
	SD	18.57	8.18			
RCS	$\bar{x}$	81.90	93.33	40.00	-1.77	0.085
	SD	24.00	17.42			
LCS	$\bar{x}$	64.76	81.43	28.76	-2.08	<u>0.047</u>
	SD	33.11	15.90			
RFS	$\bar{x}$	71.43	77.05	40.00	-1.29	0.203
	SD	16.65	10.87			
LFS	$\bar{x}$	71.43	78.19	40.00	-1.84	0.073
	SD	12.44	11.37			
RBF	$\bar{x}$	43.10	54.29	40.00	-1.56	0.128
	SD	26.39	19.77			
LBF	$\bar{x}$	42.87	55.00	40.00	-1.82	0.076
	SD	23.48	19.49			
TAS	$\bar{x}$	90.47	97.38	23.14	-1.42	0.170
	SD	21.50	6.05			

*The t tests for like variances were used in some cases. In others, it was necessary to use t tests for unlike variances.

Sentences test of Willeford's TCAF. There was a correlation between mean scores of C-TSSW and RFS and between mean scores of C-TSSW and LFS of -0.61 which is significant at the 0.003 level. The Filtered Speech test, like the SSW test, is a test of cortical function. There was a correlation between mean scores of C-TSSW and RBF of 0.52 which is significant at the 0.02 level. The Binaural Fusion test is a test of brain stem function.

In addition, the Pearson correlation matrix showed strong intra-correlations among almost all tests of Willeford's TCAF for the experimental group. There were no consistent patterns of correlations. For example, right ears and left ears correlated and tests of cortical function correlated with tests for brain stem function for the experimental group.

For the control group, however, the correlation patterns were much more consistent. Right ear scores for Katz's test correlated highly with right ear scores on Willeford's Competing Sentences and Filtered Speech tests. All of these are tests of cortical function. Right ear scores did not correlate with left ear scores, except for the Filtered Speech test. Cortical tests did not correlate with brain stem tests except for a few exceptions: The LBF correlated with C-RSSW, C-LSSW, C-TSSW, RCS, and RFS.

Discriminant Analysis

A discriminant analysis was computed to determine whether there were variables (V's) that would predict the group to which a given subject belonged. A monovariate analysis using Wilks' Lambda and Rao's

V was used. The sixteen variables used are shown in Table 2. Five variables were found essential by the discriminant analysis technique to predict the group to which a given subject belonged. The five variables were sex (V1), IQ (V3), history of ear infections (V4), C-LSSW (V6), and LBF (V13). Table 3 shows these variables with their standardized discriminant function coefficients.

As shown in Table 4, of the experimental group, seventy-one and four tenths percent (71.4%) were predicted as belonging to the group to which they were assigned. Of the control group, seventy-six and two tenths percent (76.2%) were predicted as belonging to the group to which they were assigned. Percentage of "grouped" cases correctly classified was seventy-three and eight tenths percent (73.8%).

A value of 1 was assigned to male subjects and 0 to female subjects. A value of 1 was assigned to "history of ear infections" and 0 to "no history of ear infections."

Using the standardized discriminant function coefficients for Wilks' Lambda and the scores on the five discriminant variables, discriminant scores were determined for the experimental and control groups. The data shown in Tables 5 and 6 indicate that all of the subjects correctly identified as belonging to the experimental group had negative scores. Of the twenty-one subjects, six were incorrectly classified. All of the six had positive scores. The opposite was true for the control group. All those correctly identified had positive scores and those incorrectly identified (five) had negative scores.

This information is valuable because it makes it possible to

TABLE 2

Variables Used for Wilks' Lambda and Rao's V

Variable Label	Variable
V1	Sex
V2	Age
V3	IQ
V4	History of ear infections
V5	C-RSSW
V6	C-LSSW
V7	C-TSSW
V8	RCS
V9	LCS
V10	RFS
V11	LFS
V12	RBF
V13	LBF
V14	TAS

TABLE 3

Standardized Discriminant Function Coefficients
(Wilks' Lambda)

Variable		Coefficient
V1	(Sex)	0.44037
V3	(IQ)	0.30359
V4	(History of ear infections)	-0.62416
V6	(C-LSSW)	-0.46457
V13	(LBF)	0.34571

TABLE 4

Prediction Results of Discriminant Analysis

Actual Group	Number of Cases	Number Predicted in Experimental Group	Number Predicted in Control Group
Experimental	21	15	6
		71.4%	28.6%
Control	21	5	16
		23.8%	76.2%

Percent of "grouped" cases correctly classified: 73.8%.

TABLE 5

Discriminant Scores for Wilk's Lambda
Experimental Group

Case Number	Discriminant Scores
1	0.435*
2	-0.405
3	0.469*
4	-0.141
5	-0.695
6	-1.854
7	-1.701
8	-1.304
9	0.147*
10	-1.025
11	-0.047
12	-0.102
13	-2.880
14	-1.050
15	0.301*
16	-1.210
17	0.092*
18	-0.677
19	-0.551
20	0.250*
21	-0.259

*These were incorrectly classified.

TABLE 6

Discriminant Scores for Wilk's Lambda
Control Group

Case Number	Discriminant Score
1	0.692
2	0.200
3	-1.067*
4	-0.111*
5	2.059
6	0.826
7	-0.185*
8	1.185
9	1.566
10	-0.159*
11	0.121
12	0.160
13	0.594
14	0.964
15	1.632
16	0.475
17	1.515
18	1.278
19	-0.239*
20	0.291
21	0.410

*These were incorrectly classified.

use a predictability formula that will correctly classify seventy-one and four tenths percent (71.4%) of LD children. The formula is: Y = V1(0.44037) + V3(0.30359) + V4(-0.62416) + V6(-0.46457) + V13(0.34571) where

Y = Discriminant score

V1 = Sex (M = 1, F = 0)

V3 = IQ

V4 = History of ear infections (Presence = 1, Absence = 0)

V6 = C-LSSW score

V13 = LBF score.

CHAPTER 5

DISCUSSION

Dirks (1964) suggested that if verbal dichotic tasks were used to detect CANS problems, ear laterality might "confound" the results. The terms laterality effect, ear superiority, and ear advantage are used synonymously. Since the term right ear advantage (REA) has been used throughout this paper, it will be continued to be used. Brunt (1962) noted that the SSW test is free of a clinically significant REA when administered under the usual methods. In this study a t test of significance was used to compare the right and left ears on the SSW test. No significant difference was found. Brunt felt that the reason for the SSW test being free of significant REA is that one ear always leads in time of stimulation for each item. In most dichotic listening tests, all portions of the verbal stimuli overlap in time. The fact that the SSW test items overlap only partially, allows the listener to better separate both spondaic words. The low degree of REA on the SSW test makes it a sensitive test in determining CANS dysfunction.

Katz and Illmer (1972) have noted that children with learning disabilities who failed the SSW test show at least three types of patterns:

1) the unilateral problem suggesting a severe dysfunction in auditory reception or
2) the inattention or immature pattern in which

competing items are depressed bilaterally or

3) the "A" pattern in which there is a large number of errors on first items (right or left) in the competing condition. This type of pattern has been said to suggest true dyslexia.

Table 7 shows the ranges of normal, mildly abnormal, moderately abnormal, and severely abnormal scores. According to Katz (1968), a central auditory problem is suspected if:

1) the C-TSSW score is over 15 or
2) the C-RSSW or C-LSSW score is over 20 or
3) the competing or noncompeting portion of the C-RSSW or C-LSSW score is over 25.

Subjects whose scores fall into the "mildly abnormal range" are not suspected of having central auditory problems, but are considered abnormal listeners. It is interesting to note that sixteen children (76%) in the experimental group would be classified as having unilateral problems or as being abnormal listeners compared to nine (43%) in the control group using the criteria in Table 7.

This investigation showed a significant difference between experimental and control groups on the C-LSSW when the groups were compared as a whole. This supports the first hypothesis of this study There was also a significant difference on the C-TSSW scores, probably because of the C-LSSW contribution to the total score.

Caution must be used in interpreting SSW test findings on individual children younger than eleven years of age for two reasons.

TABLE 7

Upper Limits for Corrected SSW Scores
(Katz, 1968)

C-SSW	Normal	Mildly Abnormal	Moderately Abnormal	Severely Abnormal
C-TSSW	5	15	35	100
C-RSSW or C-LSSW	10	20	40	100
Competing/Noncompeting Portions of C-RSSW or C-LSSW	15	25	45	100

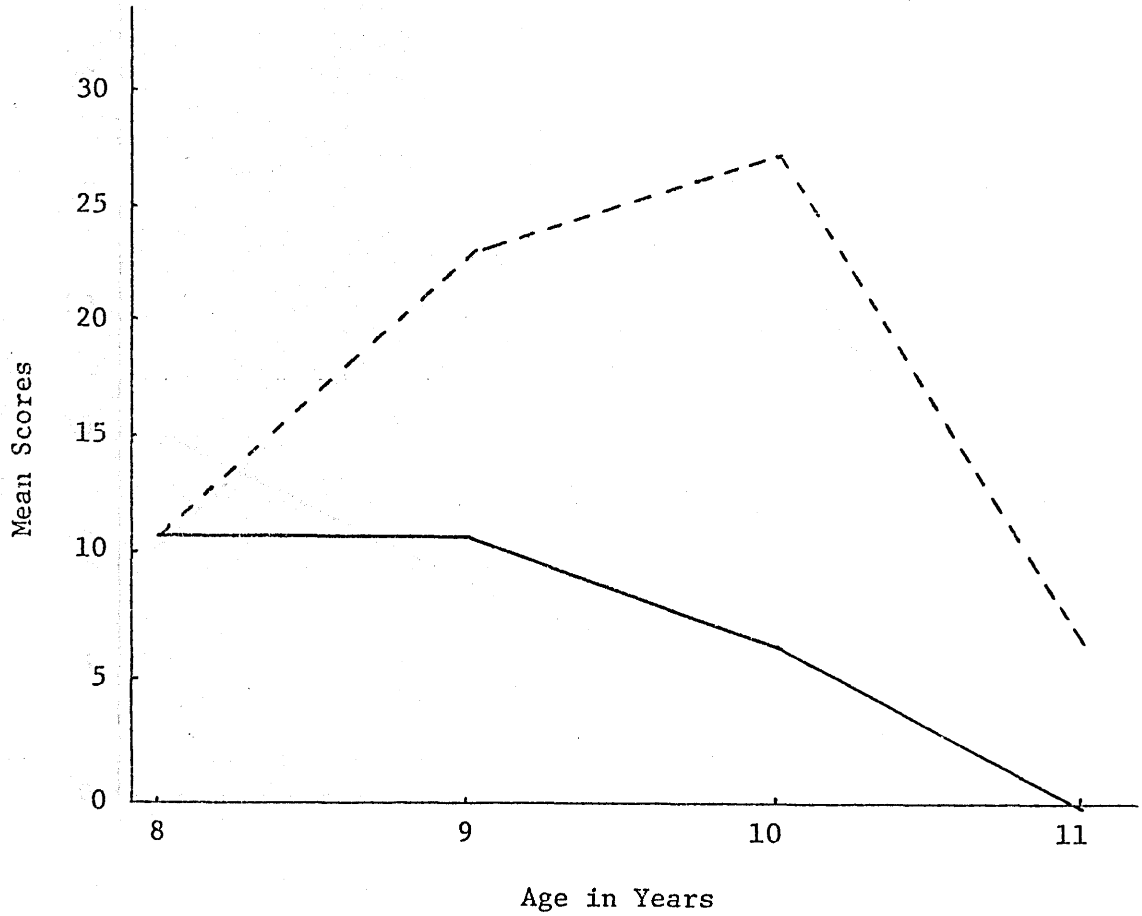
There is a significant REA which decreases with age (Katz and Myrick, 1965; Brunt, 1965). No correction formulae have been developed to remedy the REA for age.

Stubblefield and Young (1975) showed a significant difference between scores of LD and normal children on the C-RSSW as well as the C-LSSW and the C-TSSW, whereas this study showed a difference on only the C-LSSW and C-TSSW. This difference is understandable because of varying patterns of abnormal performance of LD children on the SSW test. Another reason could be differences in criteria used for classifying children as learning disabled.

In Stubblefield and Young's study, all children in the normally achieving group scored at or below the standardized limits in all categories of the SSW test. In this study subjects from both groups who were below the age of ten years showed immature patterns. The mean C-LSSW and C-TSSW scores of the control group improved as age increased (Figures 1 and 2). This is in harmony with the findings of Myrick (1965). No such maturational pattern was found for the experimental group.

There was a significant difference between experimental and control groups on the left ear scores of the CS test of Willeford's TCAF at the 0.05 level which supports the second hypothesis of this study, i.e., that there would be a significant difference between groups on the CS test. No discernible increase in test scores with increasing age could be seen in this test.

As far as this investigator knows, no studies have been con-



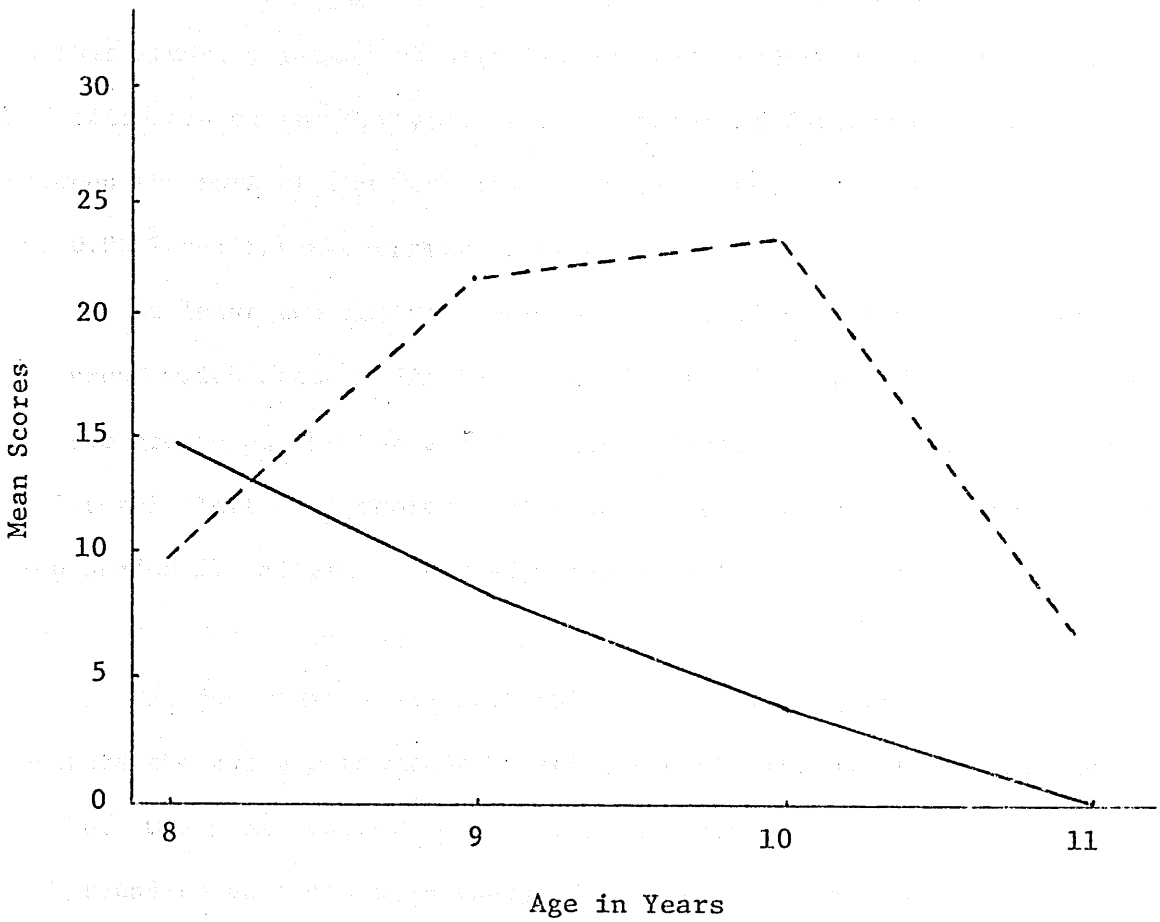
--- Experimental Group

——— Control Group

The lower the score, the better the performance.

FIGURE 1

MEAN C-LSSW SCORES BY AGE



--- Experimental Group

—— Control Group

The lower the score, the better the performance.

FIGURE 2

MEAN C-TSSW SCORES BY AGE

ducted showing the degree of REA for the CS test of Willeford's TCAF. In this study, a t test of significance was used to compare the right and left ears on the CS test. A significant difference was found between the ears at the 0.01 level for the experimental group and at the 0.02 level for the control group.

At least two factors seem to be operating within the experimental group which account for the significant left ear differences between the two groups on the SSW and CS tests. These factors are: 1) abnormal unilateral (left ear) scores indicating a dysfunction in auditory reception and/or 2) failure of ear advantages to level out with increase with age.

The fact that no identifiable points emerged in the data to separate the two groups might be attributed to the small size of the sample. One might expect age, sex, intelligence, and socioeconomic background to be factors, although Turner (1966) and Hadaway (1969) found no relationship between sex, intelligence, and socioeconomic status and SSW results. Their findings raise a question as to the necessity of matching. Nevertheless, as a precaution, the study was designed so that the groups would be matched. Although the groups in this investigation were matched for socioeconomic status on the basis of the occupation of the head of the household, they consisted of only skilled and unskilled laborers.

According to the California code, no child should be placed in an LD program unless he has at least a normal performance IQ. After the experimental sample was collected, it was found that some IQs were as old as two years. It was felt, therefore, that IQ tests should be repeated. As a result, four children with IQs lower than normal were inadvertently included in this study. The raw data are presented in Appendices D, E, F, and G.

A discriminant analysis was used to determine which, if any, variables would predict the group to which a given subject belonged. This technique showed that the two groups were distinctly different.

Individuals could not be classified on the basis of one variable alone using this technique. Five variables taken together, however, were sufficient to predict an individual as belonging to the correct group. Correct group membership was predicted for seventy-one and four tenths percent (71.4%) of the experimental group, seventy-six and two tenths percent (76.2%) of the control group, and seventh-three and eight tenths percent (73.8%) for the groups combined.

The discriminant analysis showed that all the scores for the correctly predicted experimental group were negative and all scores for the correctly predicted control group were positive. The findings of the discriminant analysis made it possible to correctly predict an LD child based on discriminant scores derived from the formula: $Y = V1(0.44037) + V3(0.30359) + V4(-0.62416) + V6(-0.46457) + V13(0.34571)$ where V1 = sex, V3 = IQ, V4 = history of ear infections, V6 = C-LSSW, and V13 = LBF.

Examination of Table 3 shows the relative loading of the various variables. It can be seen that in most instances, prediction could be made on the basis of only two variables, i.e., C-LSSW and LBF. Further, if the LBF score was high, it alone was sufficient to predict, since it contributed significantly to the positiveness of the discriminant score. Carrying this idea further, it may be possible to use the Binaural Fusion test as a screening device. If the LBF score is high, it alone would predict that the child is normally achieving. If the score is low, it would be necessary to administer the SSW test and look at the C-LSSW score.

There was a much higher incidence in the experimental group than in the control group of history of ear infections in this study. A significantly higher incidence of hearing problems has been reported for LD children than for a typical group of school-age children. Eagles, Wishik, Doerfler, Melnick, and Levine (1963) found that one to three percent of a typical group of school age children have hearing problems of a mild degree or greater. In one group of LD children between the ages of six and fourteen years, thirty-three percent (33%) had hearing problems. A few had severe unilateral hearing losses, but most had mild to moderate conductive hearing losses, many of which were fluctuating in nature. They felt that a fluctuating hearing problem could cause difficulty in acquiring normal auditory perception.

Berlin (1977) suggested that recently acquired histopathological data also support the theory that conductive hearing losses could cause central auditory dysfunction. If these findings are confirmed with further data, continuous control of middle ear problems is more important than its affect upon the peripheral auditory mechanism since such problems may actually affect development of normal central auditory function. The effect would probably be irreversible.

Summary and Conclusions

The purpose of this study was to compare the performance of normal and LD children on tests of central auditory function. Tests used were Katz's Staggered Spondaic Word (SSW) test and Willeford's Tests of Central Auditory Function (TCAF) consisting of Competing Sentences (CS) test, Filtered Speech (FS) test, Binaural Fusion (BF) test, and Alternating Speech Perception (AS) test.

Results of the study tended to indicate:

1. Experimental and control groups differed significantly on the corrected left ear scores and the corrected total scores of the SSW test, and on the left ear score of the CS test.
2. There was a high correlation between scores of LD children on the SSW test and the CS test.
3. There were high correlations among almost all tests of Willeford's TCAF for the experimental group with no consistent patterns in the correlations. Right and left ear scores correlated with one another and tests of cortical function correlated with tests of brain stem function.
4. For the control group, correlation patterns were much more consistent. Right ear scores for Katz's test correlated highly with right ear scores for Willeford's Competing Sentences test. Right ear scores did not correlate with left ear scores. Cortical tests did not correlate with

brain stem tests with a few exceptions.

5. Discriminant scores derived from five variables predicted whether an individual child belonged to the experimental or control group.
6. The LBF, when high enough, was the one variable that correctly predicted group membership. When the score was low, it was necessary to add a second variable (C-LSSW).
7. A formula was developed for deriving discriminant scores that predicted correct group membership seventy-three and eight tenths percent (73.8%) of the time.

The findings of the study can be applied only to the sample in this study.

Recommendations for Further Research

A summary of research recommendations based on the findings of this study are given below:

1. That the study be replicated using a larger sample.
2. That the study be replicated using the Binaural Fusion test of Willeford's TCAF.
3. That the study be replicated using a central auditory task modified for use with young children.
4. That a longitudinal study be conducted using a sample of children who have a history of ear infections. The data collected should include a periodic test for central auditory function.

BIBLIOGRAPHY

BIBLIOGRAPHY

Antonelli, A. R. Sensitized speech tests: results in lesions of the brain. In: Speech Audiometry, p. 176, Ed. by Rojskjaer, C., Second Danavox Symposium, Odense, 1970.

Armstrong, R. and Jensen, J. Can scores obtain from the Slosson Intelligence Test be used with as much confidence as scores obtained from the Stanford-Binet? Slosson Test Manual. East Aurora: Slosson Educational Publications, 1971.

Armstrong, R., Jensen, J., and Mooney, R. A comparison of individual intelligence tests used for special class placement. East Aurora: Slosson Educational Publications, 1974.

Berlin, C. I. The auditory system. Workshop at Long Beach Veterans Administration Hospital, Long Beach, California, January 12-14, 1977.

Berlin, C. I., Chase, R. A., Dill, A., and Hagepanos, T. Auditory findings in patients with temporal lobectomies. ASHA, 7, 386, 1965.

Berlin, C. I. and Lowe, S. S. Temporal and dichotic factors in central auditory testing. In: Handbook of Clinical Audiology, Ed. by Katz, J., Baltimore: The Williams and Wilkins Co., 280-312, 1972.

Berlin, C. I., Lowe-Bell, S. S., Cullen, J. K., Jr., Thompson, C. L., and Loovis, C. F. Dichotic speech perception: an interpretation of right-ear advantage and temporal offset effects. Journal of the Acoustical Society of America, 53, 699-709, 1973.

Berlin, C. I. and McNeil, M. R. Dichotic listening. In: Contemporary Issues in Experimental Phonetics, Ed. by Lass, N., New York: Academic Press, 327-387, 1976.

Bocca, E. Clinical aspects of cortical deafness. Laryngoscope, 68, 301-309, 1958.

Bocca, E. Factors influencing binaural integration of periodically switched messages. Acta-Otolaryngologica, 53, 142-144, 1961.

Bocca, E. and Calearo, C. Central hearing processes. In: Modern Developments in Audiology, Ed. by Jerger J., New York: Academic Press, 337-370, 1963.

Bocca, E., Calearo, C., and Cassinari, V. A new method for testing hearing in temporal lobe tumours, a preliminary report. Acta-Otolaryngologica, 44, 219-221, 1954.

Bocca, E., Calearo, C., Cassinari, V., and Migliavacca, F. Testing "cortical" hearing in temporal lobe tumours. Acta-Otolaryngologica, 45, 289-304, 1955.

Broadbent, D. E. The role of auditory localization in attention and memory span. Journal of Experimental Psychology, 45, 191-196, 1954.

Brunt, M. A. Performance on three auditory tests by children with functional articulation disorders. Unpublished master's thesis, University of Pittsburgh, 1965, cited by Brunt, M. A. In: Handbook of Clinical Audiology, p. 352, Ed. by Katz, J., Baltimore: The Williams and Wilkins Co., 1972.

Brunt, M. A. The staggered spondaic word test. In: Handbook of Clinical Audiology, Ed. by Katz, J., Baltimore: The Williams and Wilkins Co., 334-356, 1972.

Calearo, C. Binaural summation in lesions of the temporal lobe. Acta-Otolaryngologica, 47, 392-395, 1957.

Calearo, C. and Antonelli, A. R. Audiometric findings in brainstem lesions, Acta-Otolaryngologica, 66, 305-319, 1968.

Calearo, C. and Antonelli, A. R. "Cortical" hearing tests and cerebral dominance. Acta-Otolaryngologica, 56, 17, 1963.

Calearo, C. and Lazzaroni, A. Speech intelligibility in relation to the speed of the message. Laryngoscope, 67, 410, 1957.

California. Education Code, 1976.

Cherry, E. C. and Taylor, W. K. Some further experiments upon the recognition of speech, with one and with two ears. Journal of Acoustical Society of America, 26, 554, 1954.

Cullen, J. K., Jr., Thompson, C. L., Hughes, L. F., Berlin, C. I., and Samson, D. S. The effects of varied acoustic parameters on performance in dichotic speech perception tasks. Brain and Language, 1, 307-322, 1974.

Dirks, D. Perception of dichotic and monaural verbal material and cerebral dominance for speech. Acta-Otolaryngologica, 58, 73-80, 1974.

Eagles, E. L., Wishik, S. M., Doerfler, L. G., Melnick, W., and Levine, H. A. Hearing sensitivity and related factors in children. Laryngoscope, Supplement, 1963.

Fairbanks, G., Guttman, N., and Miron, M. S. Effect of time-compression upon the comprehension of connected speech. Journal of Speech and Hearing Disorders, 22, 10, 1957.

Garvey, W. D. The intelligibility of speeded speech, Journal of Experimental Psychology, 45, 102, 1953.

Gerber, S. E. and Goldman, P. Ear preference for dichotically presented verbal stimuli as a function of report strategies. Journal of the Acoustical Society of America, 49, 1163-1168, 1971.

Hadaway, S. An investigation of the relationship between measured intelligence and performance on the Staggered Spondaic Word test. Unpublished master's thesis, Oklahoma State University, 1969, cited by Brunt, M. A. In: Handbook of Clinical Audiology, p. 344, Ed. by Katz, J., Baltimore: The Williams and Wilkins Co., 1972.

Hayashi, R., Ohta, F., and Morimoto, M. Binaural fusion test: a diagnostic approach to the central auditory disorders. International Audiology, 5, 133, 1966.

Jerger, J. Auditory tests for disorders of the central auditory mechanism. In: Neurological Aspects of Auditory and Vestibular Disorders, p. 77, Ed. by Fields, S. and Alford, B. R., Springfield: Charles C. Thomas, 1964.

Jerger, J. Auditory manifestations of lesions in the auditory nervous system, Laryngoscope, 70, 417, 1960.

Jerger, J. Diagnostic significance of SSI test procedures: retrocochlear site. In: Speech Audiometry, p. 163, Ed. by Rojskjaer, C., Second Danavox Symposium, Odense, 1970.

Jerger, J., Mier, M., Boshes, B., and Cantor, G. Auditory behavior in Parkinsonism, Acta-Otolaryngologica, 52, 541-550, 1960.

Katz, J. The SSW test: an interim report. Journal of Speech and Hearing Disorders, 33, 132, 1968.

Katz, J. The use of staggered spondaic words for assessing the integrity of the central auditory nervous system. Journal of Auditory Research, 11, 327-337, 1962.

Katz, J., Basil, R. A., and Smith, J. N. A staggered spondaic word test for detecting central auditory lesions. Annals of Otolaryngology, 72, 908, 1963.

Katz, J. and Illmer, R. Auditory perception in children with learning disabilities. In: Handbook of Clinical Audiology, Ed. by Katz, J., Baltimore: The Williams and Wilkins Co., 540-563, 1972.

Katz, J. and Myrick, D. K. A normative study to assess performance of a group of children, aged seven through eleven, on the Staggered Spondaic Word (SSW) test. Unpublished study, 1965. In: Handbook of Clinical Audiology, p. 352, Ed. by Katz, J., Baltimore: The Williams and Wilkins Co., 1972.

Kimura, D. Some effects of temporal-lobe damage on auditory performance. Canadian Journal of Psychology, 15, 156-165, 1961a.

Kimura, D. Cerebral dominance and the perception of verbal stimuli, Canadian Journal of Psychology, 15, 166-171, 1961b.

Korsan-Bengtsen, M. The diagnosis of hearing loss in old people. In: Geriatric Audiology, Ed. by Liden, G., Almquist and Wiksell, Stockholm, 1968.

Korsan-Bengtsen, M. Distorted speech audiometry. Acta-Otolaryngologica, Supplementum #310, 1973.

Korsan-Bengtsen, M. Some comparisons between ordinary and sensitized speech tests in patients with central hearing loss. In: Speech Audiometry, p. 123, Ed. by Rojskjaer, C., Second Danavox Symposium, Odense, 1970.

Martin, F. N. Pure tone audiometry, Introduction to Audiology. Englewood Cliffs: Prentice-Hall, Inc., 69-123, 1975.

Matzker, J. Two new methods for the assessment of central auditory functions in cases of brain disease. Annals of Otolaryngology, 68, 1185-1197, 1959.

Matzker, J. and Ruckes, J. Diagnosis of morphologically demonstrable brainstem diseases by a new hearing test. Abstracted Excerpta Medicus, 11, 409, 1958.

Mencher, G. T., Clack, T. D., and Rupp, R. R. The difference limen for intensity and central auditory pathology. Journal of Auditory Research, 10, 372-377, 1970.

Myrick, D. K. A normative study to assess performance of a group of children ages seven through eleven on the Staggered Spondaic Word test. Unpublished master's thesis, Tulane University, 1965, cited by Katz, J. and Illmer, R. In: Handbook of Clinical Audiology, p. 551, Ed. by Katz, J. Baltimore: The Williams and Wilkins Co., 1972.

Nylen, C. O. The oto-neurological diagnosis of tumours of the brain. Acta-Otolarynogologica (Helsingfors) Supplementum #33, 114, 1939.

Oxbury, J. M. and Oxbury, S. M. Effects of temporal lobectomy on the report of dichotically presented digits. Cortex, 5, 3, 1969.

Penfield, W. and Roberts, L. Speech and Brain Mechanisms. Princeton: Princeton University Press, 1959.

Quiros de, J. B. Accelerated speech audiometry: an examination of test results. Translations of the Beltone Institute for Hearing Research, 1964.

Ryan, W. and McNeil, M. Listener reliability for a dichotic listening task. Journal of the Acoustical Society of America, 56, 1922-1923, 1974.

Smith, B. B. and Resnick, D. M. An auditory test for assessing brain-stem integrity: preliminary report. Laryngoscope, 82, 414-424, 1972.

Stubblefield, J. H. and Young, C. E. Central auditory dysfunction in learning disabled children. Journal of Learning Disabilities, 8, 32-37, 1975.

Sussman, H. M. The laterality effect in lingual-auditory tracking. Journal of the Acoustical Society of America, 49, 1874-1880, 1971.

Triesman, A. M. and Geffen, G. Selective attention and cerebral dominance in perceiving and responding to speech messages. Quarterly Journal of Experimental Psychology, 20, 139-150, 1968.

Turner, L. A normative study on the SSW test for various age groups. Unpublished master's thesis, University of Kansas, 1966, cited by Brunt, M. A. In: Handbook of Clinical Audiology, p. 343, Ed. by Katz, J., Baltimore: The Williams and Wilkins Co., 1972.

Willeford, J. A. Central auditory function in children with learning disabilities. Audiology and Hearing Education, 2, 12-20, 1976.

APPENDICES

APPENDIX A

WILSON RILES
Superintendent of Public Instruction
and Director of Education

LESLIE BRINEGAR
Director
Office of Special Education

California State Department of Education
721 Capitol Mall
Sacramento, California 95814

SELECTED CALIFORNIA ADMINISTRATIVE CODE (CAC), TITLE 5, PROVISIONS
PERTAINING TO PROGRAMS FOR EDUCATIONALLY HANDICAPPED PUPILS
Effective February 28, 1976

- DISTRIBUTED BY: Office of Riverside County Superintendent of Schools
Division of Special Schools and Services
A. Morton Saske, Director - Pupil Personnel Services

(2) Perform follow-up activities involved in specific intervention techniques with the pupil's family.

(3) Provide for the adjustment of the pupil in a regular classroom setting.

(j) Provides for parent counseling and parent education which will offer opportunities to become involved in the program planning of their pupil.

(k) Provides for a written parent appeal process which procedure shall be approved by the Superintendent of Public Instruction available in English and in the primary language of the pupil's home.

(l) Provides for regular reports of pupil progress to the parent or guardian.

(m) Class(es) shall be physically located in facilities in close proximity to the general school population to promote maximum interaction with other pupils.

Article 3. Eligibility, Assessment, and Program Planning

3230. Eligibility of Pupils for Admission to a Program. An educationally handicapped pupil described in Education Code Sections 6750, 6750.1, and 6755 is eligible for admission to a program if the pupil's handicap(s) has been determined by the admission committee to be one or more of the following specific disabilities:

(a) Learning Disability to which all of the following apply:

(1) Specific learning disabilities in the psychological, mental, or physiological process which involve interference in understanding spoken or written language. Such learning disabilities include, but are not limited to, those sometimes referred to as perceptual handicaps, minimal brain dysfunction, dyslexia, dyscalculia, dysgraphia, or communication disorders, except asphasic as defined in Section 3600(g) of this title.

(2) The specific learning disabilities are of such severity that they interfere with the learning of the basic skills expected of pupils of similar age, and evidence is presented that upon amelioration of such disabilities a favorble prognosis may be made for the reduction of the discrepancy between the pupil's ability and level of functioning in the learning skills.

(3) Where the general level of academic functioning is below expectation for the pupil, such delay shall not be attributable to mental retardation for academic learning.

(4) The specific learning disabilities shall be determined by a complete evaluation accompanied by recommendations for the amelioration of the learning disorder that can be carried out within the class or program recommended.

(b) Behavior Disorder to which all of the following apply:

(1) The specific behavior disorder(s) is of such a nature that the pupil cannot benefit from the regular educational program. Such behavior disorders include, but are not limited to, those sometimes referred to as excessive fears, explosive reactions, anxieties, withdrawal reactions, perseveration, and compulsive reactions.

(2) The specific behavior disorders are of such prolonged severity that they interfere with the learning of the basic skills expected of pupils of similar age, and evidence is presented that upon amelioration of such disabilities a favorable prognosis may be made for the reduction of the discrepancy between the pupil's ability and level of functioning in the learning skills.

(3) The specific behavior disorders shall be determined by a psychiatric or psychological evaluation accompanied by recommendations for the amelioration of the behavior disorder that can be carried out within the class or program recommended.

(4) The admission committee finds the pupil's specific behavior disorder(s) is not solely a problem behavior as defined in Division 6, Chapter 7, Articles 1, 4, and 5, commencing with Sections 6500, 6651, and 6701 respectively, Chapter 7 (commencing with Section 12551) of Division 9 of the Education Code.

(c) A Serious Emotional Disturbance to which all of the following apply:

(1) The serious emotional disturbance is of such a nature that the pupil cannot attend a regular education program. Included among others, are pupils who exhibit, to a marked degree, one or more of the following characteristics:

(A) Severe disturbance in learning that cannot be explained by intellectual, sensory or health factors.

(B) Severe disturbance in relationships with peers and adults.

(C) Severe disturbance in behavior or affect under normal circumstances.

(D) A pervasive and prolonged state of depression or anxiety.

(E) A constant or prolonged display of psychosomatic symptoms.

APPENDIX B

Description of Sample
Experimental Group

Case Number	Sex	Age	IQ	History of Ear Infections
1	M	8-01	103	-
2	F	8-07	93	+
3	M	8-11	91	-
4	M	9-02	106	-
5	M	9-03	100	+
6	F	9-05	71	-
7	M	9-05	100	+
8	M	9-08	90	+
9	M	9-08	110	-
10	M	9-10	89	+
11	M	10-01	80	-
12	M	10-02	115	+
13	M	10-04	72	+
14	M	10-05	98	-
15	M	11-02	106	-
16	M	11-02	86	+
17	M	11-03	77	-
18	M	11-03	104	+
19	M	11-08	94	+
20	M	11-11	103	-
21	M	12-01	107	+

APPENDIX C

Description of Sample
Control Group

Case Number	Sex	Age	IQ	History of Ear Infections
1	M	8-01	110	-
2	F	8-08	104	+
3	M	8-10	103	+
4	M	9-02	95	-
5	F	9-02	112	-
6	M	9-04	111	-
7	M	9-06	93	-
8	M	9-07	115	-
9	M	9-08	117	-
10	M	10-01	84	-
11	M	10-07	108	-
12	M	10-08	108	+
13	M	10-09	96	-
14	M	10-11	108	-
15	M	11-00	112	-
16	M	11-06	96	-
17	M	11-06	115	-
18	M	11-06	114	-
19	M	11-10	102	+
20	M	11-11	93	-
21	M	12-00	92	-

APPENDIX D

Raw Staggered Spondaic Word Test Scores
Experimental Group

Case Number	C-RSSW	C-LSSW	C-TSSW
1	8	11	10
2	9	11	10
3	11	10	10
4	8	12	10
5	16	11	14
6	84	84	84
7	4	16	10
8	18	15	16
9	2	11	6
10	13	10	12
11	20	10	15
12	2	4	3
13	28	42	35
14	27	54	40
15	0	5	2
16	7	11	9
17	8	8	8
18	4	6	5
19	0	1	0
20	20	12	16
21	- 1	5	2

APPENDIX E

Raw Staggered Spondaic Word Test Scores
Control Group

Case Number	C-RSSW	C-LSSW	C-TSSW
1	0	11	6
2	56	8	32
3	4	13	8
4	18	12	15
5	18	14	16
6	10	10	10
7	− 2	18	8
8	0	4	2
9	− 2	6	2
10	1	12	6
11	8	18	13
12	2	− 3	0
13	0	− 3	− 2
14	− 4	8	2
15	2	−11	− 4
16	0	1	0
17	1	6	4
18	− 4	0	− 2
19	5	0	2
20	− 3	2	0
21	2	5	4

APPENDIX F

Raw Tests of Central Auditory Function Scores
Experimental Group

Case Number	RCS	LCS	RFS	LFS	RBF	LBF	TAS
1	90	70	74	76	15	50	100
2	40	50	32	38	25	0	45
3	100	70	78	76	50	70	100
4	90	30	64	62	45	10	100
5	80	60	66	68	35	65	100
6	0	0	32	42	10	0	15
7	90	100	70	68	65	10	100
8	80	60	50	66	0	50	95
9	90	80	74	76	55	20	95
10	80	80	68	74	35	60	90
11	60	90	78	84	70	55	90
12	90	90	80	84	80	65	100
13	90	0	62	70	10	30	75
14	70	0	70	64	25	45	100
15	100	80	80	80	40	25	95
16	100	100	84	76	75	55	100
17	100	90	88	84	85	65	100
18	100	90	82	80	45	50	100
19	90	80	86	78	75	65	100
20	80	40	88	70	5	40	100
21	100	100	94	84	60	70	100

APPENDIX G

Raw Tests of Central Auditory Function Scores
Control Group

Case Number	RCS	LCS	RFS	LFS	RBF	LBF	TAS
1	100	80	74	68	55	55	90
2	20	70	42	56	60	15	75
3	90	60	78	80	65	30	100
4	100	80	82	86	70	60	100
5	100	80	88	78	95	90	100
6	100	90	84	84	70	50	100
7	100	90	82	82	35	40	100
8	100	70	60	56	20	35	90
9	100	100	88	84	60	65	100
10	90	60	72	76	50	40	95
11	90	40	74	62	55	45	100
12	100	70	88	76	55	80	100
13	100	70	84	82	35	70	100
14	90	90	84	96	45	45	100
15	90	100	68	82	30	70	100
16	100	100	74	62	45	45	100
17	100	100	82	82	80	90	100
18	100	90	74	86	65	65	95
19	90	90	76	82	75	55	100
20	100	90	76	96	60	70	100
21	100	90	88	86	15	40	100

APPENDIX H

Means and Standard Deviations
Experimental Group

Variable	Cases	Mean	Standard Deviation
V5	21	13.7143	18.2377
V6	21	16.6190	19.7192
V7	21	15.0952	18.5685
V8	21	81.9048	24.0040
V9	21	64.7619	33.1088
V10	21	71.4286	16.6512
V11	21	71.4286	12.4444
V12	21	43.0952	26.3854
V13	21	42.8571	23.4825
V14	21	90.4762	21.5004

APPENDIX I

Means and Standard Deviations
Control Group

Variable	Cases	Mean	Standard Deviation
V5	21	5.3333	13.1428
V6	21	6.2381	7.3818
V7	21	5.8095	8.1769
V8	21	93.3333	17.4165
V9	21	81.4286	15.9016
V10	21	77.0476	10.8743
V11	21	78.1905	11.3650
V12	21	54.2857	19.7665
V13	21	55.0000	19.4936
V14	21	97.3810	6.0457

APPENDIX J

Means and Standard Deviations
Combined Groups

Variable	Cases	Mean	Standard Deviation
V5	21	9.5238	16.2634
V6	21	11.4286	15.6160
V7	21	10.4524	14.9294
V8	21	87.6190	21.5056
V9	21	73.0952	27.0040
V10	21	74.2381	14.1782
V11	21	74.8095	12.2580
V12	21	48.6905	23.7122
V13	21	48.9286	22.1837
V14	21	93.9286	15.9855

APPENDIX K

Pearson Correlation Matrix for Relationships between Mean Scores of SSW Test and TCAF
Experimental Group

	C-RSSW	C-LSSW	C-TSSW	RCS	LCS	RFS	LFS	RBF	LBF	TAS
C-RSSW	1.0000	0.9130	0.9774	-0.8222	-0.7064	-0.6147	-0.6000	-0.5186	-0.3704	-0.7679
C-LSSW		1.0000	0.9784	-0.7072	-0.7890	-0.5818	-0.5996	-0.4940	-0.4532	-0.6871
C-TSSW			1.0000	-0.7812	-0.7645	-0.6121	-0.6138	-0.5186	-0.4209	-0.7434
RCS				1.0000	0.5479	0.7835	0.7838	0.4244	0.5265	0.8895
LCS					1.0000	0.5856	0.6574	0.7120	0.4607	0.5199
RFS						1.0000	0.9008	0.5812	0.6642	0.8067
LFS							1.0000	0.5797	0.7296	0.7822
RBF								1.0000	0.3784	0.4071
LBF									1.0000	0.6137
TAS										1.0000

APPENDIX L

Pearson Correlation Matrix for Relationships between Mean Scores of SSW Test and TCAF
Control Group

	C-RSSW	C-LSSW	C-TSSW	RCS	LCS	RFS	LFS	RBF	LBF	TAS
C-RSSW	1.0000	0.2202	0.9004	-0.8614	-0.2058	-0.6820	-0.3908	0.1405	-0.5591	-0.7279
C-LSSW		1.0000	0.6204	-0.0376	-0.5398	-0.1689	-0.4094	0.0680	-0.4361	-0.2654
C-TSSW			1.0000	-0.7080	-0.4016	-0.6218	-0.4989	0.1461	-0.6321	-0.7085
RCS				1.0000	0.2528	0.7674	0.4261	-0.0581	0.5375	0.7994
LCS					1.0000	0.2512	0.4632	0.0193	0.3549	0.2489
RFS						1.0000	0.6505	0.1642	0.5661	0.8500
LFS							1.0000	0.1520	0.4266	0.6189
RBF								1.0000	0.4217	0.0673
LBF									1.0000	0.5197
TAS										1.0000

APPENDIX M

Pearson Correlation Matrix for Relationships between Mean Scores of SSW Test and TCAF Combined Groups

	C-RSSW	C-LSSW	C-TSSW	RCS	LCS	RFS	LFS	RBF	LBF	TAS
C-RSSW	1.0000	0.7594	0.9414	-0.8471	-0.6030	-0.6534	-0.5488	-0.3318	-0.4804	-0.7305
C-LSSW		1.0000	0.9338	-0.5837	-0.7742	-0.5182	-0.5564	-0.4058	-0.4771	-0.6659
C-TSSW			1.0000	-0.7669	-0.7301	-0.6267	-0.5895	-0.3927	-0.5059	-0.7470
RCS				1.0000	0.5086	0.7874	0.6644	0.3022	0.5646	0.8296
LCS					1.0000	0.5293	0.6097	0.5531	0.4678	0.5136
RFS						1.0000	0.8056	0.4696	0.6445	0.7857
LFS							1.0000	0.4434	0.6293	0.6879
RBF								1.0000	0.4343	0.3598
LBF									1.0000	0.5710
TAS										1.0000

APPENDIX N

Pearson Correlation Matrix for Relationships between Mean Scores of SSW Test and TCAF
Levels of Significance
Experimental Group

	C-RSSW	C-LSSW	C-TSSW	RCS	LCS	RFS	LFS	RBF	LBF	TAS
C-RSSW	0.001	0.001	0.001	0.001	0.001	0.003	0.004	0.016	0.098	0.001
C-LSSW		0.001	0.001	0.001	0.001	0.006	0.004	0.023	0.039	0.001
C-TSSW			0.001	0.001	0.001	0.003	0.003	0.016	0.057	0.001
RCS				0.001	0.010	0.001	0.001	0.055	0.014	0.001
LCS					0.001	0.005	0.001	0.001	0.036	0.016
RFS						0.001	0.001	0.006	0.001	0.001
LFS							0.001	0.006	0.001	0.001
RBF								0.001	0.091	0.067
LBF									0.001	0.003
TAS										0.001

APPENDIX O

Pearson Correlation Matrix for Relationships between Mean Scores of SSW Test and TCAF
Levels of Significance
Control Group

	C-RSSW	C-LSSW	C-TSSW	RCS	LCS	RFS	LFS	RBF	LBF	TAS
C-RSSW	0.001	0.337	0.001	0.001	0.371	0.001	0.080	0.544	0.008	0.001
C-LSSW		0.001	0.003	0.871	0.012	0.464	0.065	0.769	0.048	0.245
C-TSSW			0.001	0.001	0.071	0.003	0.021	0.528	0.002	0.001
RCS				0.001	0.269	0.001	0.054	0.802	0.012	0.001
LCS					0.001	0.272	0.034	0.934	0.114	0.277
RFS						0.001	0.001	0.477	0.007	0.001
LFS							0.001	0.511	0.054	0.003
RBF								0.001	0.057	0.772
LBF									0.001	0.016
TAS										0.001

APPENDIX P

Pearson Correlation Matrix for Relationships between Mean Scores of SSW Test and TCAF
Levels of Significance
Combined Groups

	C-RSSW	C-LSSW	C-TSSW	RCS	LCS	RFS	LFS	RBF	LBF	TAS
C-RSSW	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.032	0.001	0.001
C-LSSW		0.001	0.001	0.001	0.001	0.001	0.001	0.008	0.001	0.001
C-TSSW			0.001	0.001	0.001	0.001	0.001	0.010	0.001	0.001
RCS				0.001	0.001	0.001	0.001	0.052	0.001	0.001
LCS					0.001	0.001	0.001	0.001	0.002	0.001
RFS						0.001	0.001	0.002	0.001	0.001
LFS							0.001	0.003	0.001	0.001
RBF								0.001	0.004	0.019
LBF									0.001	0.001
TAS										0.001